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Win-win scenarios at the climate–development interface: Challenges and opportunities for stove replacement programs through carbon finance

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ABSTRACT

Achieving win-win outcomes in environment–development programs is a laudable goal, but frequently difficult to realize. In this paper we review the possibilities for win-win climate and development outcomes in programs that distribute improved cookstoves with the use of carbon finance. We show that improved cookstove technologies form an important, if asymmetrical, environment–development interface, and illustrate the mutually supported local (development) and global (climate change) benefits of continued improved stoves use—where success in one program area is directly tied to benefits in the other. We also describe how program results are highly contextual and that, in practice, there are a number of challenges to achieving effective 'win-win' outcomes—including cultural, financial, governance and technological barriers. While carbon finance provides an opportunity to fund scaleable and enforceable stove programs, it may also introduce mutually supported impediments—where progress towards one set of program objectives, directly compromises progress towards other objectives. Drawing on development debates for improved cookstove use, scientific reports on stove-based greenhouse gas reductions, and preexisting case studies of carbon and non-carbon financed cookstoves in Peru, Uganda and Cambodia, we conclude that the challenge for future carbon financed improved cookstove projects will be to leverage inherent symbioses between climate and development arenas in order to overcome mutually supported impediments. Achieving substantive win-win conditions will require further scholarly and practical engagement to tackle the many outstanding challenges and uncertainties reviewed in this essay.

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1. Introduction

One of the most notable, if underreported, accomplishments of the 2009 United Nations Conference on Climate Change in Copenhagen (COP15) was the establishment of the Safe Access to Firewood and Alternative Energy in Humanitarian Settings (SAFE) stoves initiative. The SAFE Stoves Project was created to scale up distribution of low polluting and more fuel-efficient stoves, beginning with test programs in Sudan and Uganda in 2010. At first glance, this appears to be an unlikely achievement for a gathering organized around pressing climate science and policy issues. The SAFE stoves program, however, reflects recent findings by both climate and development experts: domestic cookstoves in the developing world present a valuable opportunity to combat climate change and rural livelihood issues *simultaneously*. Indeed, according to UN Secretary General, Ban Ki-moon, the SAFE Stoves project "shows a virtuous circle in action, thanks to technology; environmental protection, improved safety for women, access to clean energy for the poor, enhanced climate security". The Secretary General went on to note the ability of SAFE Stoves, ostensibly a rural development intervention, to effectively address the causes and consequences of climate change and thus serve as "a simple, inexpensive and win-win solution". Testament to these synergies are other emerging multi-objective programs, such as the United Nations Foundation's Global Alliance for Clean Cookstoves launched in late 2010 which strives to bring clean stove and fuel options to 100 million homes by 2020 (Calvin, 2010).

Over half the world's population rely on biomass burning stoves for domestic cooking and heating activities. Globally, over 1.5 million people, the majority of whom are rural women and children, die each year due to complications resulting from exposure to harmful pollutants emanating from traditional stoves (WHO, 2006). In response to these health concerns, numerous programs have been implemented in developing nations to replace traditional stoves with clean and efficient varieties (NCAER, 2002; Smith, 1993; Barnes et al., 1993, 1994; Bailis et al., 2009; Sagar and Kartha, 2007). About 828 million people now use improved

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cookstoves (ICS) on a daily basis (UNDP/WHO, 2009). Recent climate science studies also identify domestic cookstoves as a significant source of green house gas emissions (GHGs) (Smith et al., 2000). Replacing traditional stoves with cleaner varieties thus raises the possibility of mitigating indoor air pollution while also reducing greenhouse gas emissions (Smith and Haigler, 2008). As a result, there is increasing agreement within development and climate science communities that stove replacement programs can function as a "win-win" solution to pressing climate and development concerns (Adler, 2010; GTZ, 2011; Sagar & Kartha, 2007; Panwar et al., 2009; Edwards et al., 2004). The ability to reduce greenhouse gas emissions through improved cookstove programs has also meant that carbon offset financing has begun flowing into stove projects in order to generate emissions reductions credits (Mann, 2007; Bumpus, 2009). As is the case with any new development paradigm, however, many uncertainties exist.

This paper sets out to review this win-win scenario and examine its potential to bring meaningful and far-reaching benefits to households and the wider global community. We ask: what are the major barriers to, and benefits of, replacing stoves through a carbon financing approach? What does a win-win approach to stove dissemination portend for greenhouse gas reductions and, of particular interest to this study, how might this approach influence development outcomes at the community and household level—what Forsyth (2007) refers to as "development dividends"? Given the nascence of carbon financed improved cookstoves projects, and thus the limited number of successfully implemented projects and case studies to use for empirical analysis, we provide a review of current thinking on the possibilities and pitfalls of including carbon finance in cookstove programs. It is, however, precisely *because* of the emerging nature of these programs that we are presented with an opportunity to analyze early trends and generate influential findings.

Drawing on resources and case studies from rural development, climate policy and carbon finance literatures, this essay proffers three principle findings that characterize emerging issues at the improved cookstove climate–development interface:

- Achieving win-win outcomes for carbon financed improved cookstove projects requires effective articulation of both development and climate-related program objectives.
- Although climate benefits are significantly more modest than development benefits in the win-win equation, co-pursuing climate and development objectives can generate context-dependent, mutually supported *benefits* that enhance efforts to achieve success within both program areas.
- Improved cookstove programs using carbon financing may also generate mutually supported *impediments* that obscure diverse user needs, encumber more nimble distribution approaches, reduce dedicated stove use and, ultimately, undermine success within each program area.

In Section 2 we outline current debates concerning the use and meaning of "win-win" as a descriptor and outcome of development programs. In Section 3 we briefly discuss the emergence of such win-win formulations within development and climate mitigation communities. Section 4 reviews the primary challenges facing carbon financed improved cookstove programs in terms of achieving both climate and development "wins". In Section 5 we articulate pathways for win-win outcomes. Section 6 uses brief summaries to describe some of the accomplishments, implications and problems associated with three ongoing carbon-financed stove distribution projects. Section 7 briefly discusses the need to promote sustained stove use through the careful negotiation of mutually supported benefits and impediments. Finally we conclude, in Section 8, with a review of our findings and discuss standing debates that may impede or enable the implementation of methodologically sound, sustainable and equitable projects.

2. Environment–development and the win-win debate

The pursuit of win-win outcomes in development policy is commonplace and refers to conditions where proposed actions generate benefits for targeted communities while simultaneously advancing the objectives of third party entities or other development agendas (also referred to as "co-benefits"). From an efficiency standpoint, constructing development around win-win objectives maximizes the delivery of benefits by reaching multiple and diverse groups. From a practical standpoint, development projects are more likely to receive institutional funding and support if numerous beneficial outcomes can be packaged within a single development program. From a political standpoint, this can have the effect of stemming opposition by attending to the needs of groups who might otherwise challenge single objective-oriented development programs.

Numerous studies, however, view win-win scenarios with considerable skepticism. Scenarios where "everyone wins" are considered a rhetorical tool for placating local concerns in order to advance a single privileged agenda, while leaving certain populations by the wayside (Redford and Stearman, 1993; Cooke and Kothari, 2001; Hickey and Mohan, 2004; Tsing, 2005; Olsen, 2007; Hirsch et al., 2010). "Pro poor", "intermediate" and "appropriate" technologies, presented as affordable, efficient, and simple to use (Patterson et al., 2007; Shriar, 2007), may in fact emphasize centralized knowledge over indigenous perspectives and deprioritize investments in low-cost technology programs (Baker and Edmonds, 2004; Grieve, 2004; Schenk Sandbergen, 1991). Others suggest that technology-based development programs, from tubewells to transgenic seeds, generate clear patterns of uneven development (e.g. Dubash, 2002; Baker and Jewitt, 2007; Jewitt and Baker, 2007; Birkenholtz, 2008). According to Simon (2010), win-win programs succeed or fail for certain groups depending on the organizational structure, interrelationships and distribution of decision-making control embedded within development partnerships. Technology applications are not one-size fits all: they will tend to produce innovation successes and failures within and across diverse geographies and social categories.

Thirty years of cookstove projects in India illustrates the many struggles and opportunities associated with structuring development around win-win objectives (Kishore and Remana, 2002; Hanbar and Karve, 2002; Rehman & Malhotra, 2004). Projects in the 1980s and early 1990s emphasized the dissemination of fuel-efficient stoves to slow rates of deforestation, but largely sidelined efforts to reduce pollution in the cooking environment as devices were often installed in ways that produced more smoke than traditional models (Tilak et al., 1986; Zhang et al., 1999; Smith, 2000; IPCC, 2007). Over the past decade, win-win development objectives have emphasized indoor air pollution reductions alongside rural market reforms through the financing and expansion of stove markets (Shell Foundation, 2005; World Bank, 2002a). Although stoves are typically compatible with household cooking requirements, these projects have resulted in market entrenchment, higher stove prices and access problems for disadvantaged households (Simon, 2009).

Win-win debates are also clearly visible in the broader climate–development agenda. As Campbell (2009, p398) notes, "a world characterized by win-win opportunities is being promoted .... [But] [i]n many cases win-win outcomes will not be feasible and there will be winners and losers in rural areas. There are a multiple of trade-offs (*sic*) to be understood and negotiated". One analysis of supposed win-win environment–development programs, noted that only 16% of projects made major progress on both objectives (Tallis et al., 2008). Reducing Emissions from Deforestation and Degradation (REDD) is one of the emerging climate–development interfaces that holds distinct possibilities for win-win in local development and global climate mitigation, but is complex in its practical articulation (Campbell, 2009; Agrawal and Angelsen, 2009). Who defines win-win objectives and policies, and the ability to understand trade-offs is critical for potential success (Adams and Hulme, 2001).

It is with this framework that the remainder of the essay proceeds to examine the emergence of cookstove development projects structured around the dual objectives of climate change and indoor air pollution mitigation. Our analysis is situated within broader environment–development win-win debates surrounding the contribution of carbon financing to both greenhouse gas emissions reductions and development (Olsen and Fenhann, 2008a,b; Wara and Victor, 2008), and emerging analyses on carbon finance and cookstoves (Bumpus, 2009) and cookstove-based development (Simon, 2009, 2010). We ask: why now? What do stove distribution projects operating at the climate–development interface look like? And what emerging challenges, opportunities and uncertainties arise that may impede or propel projects toward successful, efficient and equitable outcomes?

3. Why now? The emergence of carbon markets

Over the past decade, numerous reports have examined the relationship between stoves, emissions and human health. These studies describe the health consequences of indoor air pollution on women and children responsible for cooking activities (WHO, 2002; Bruce, 2003; Smith, 2002; Wilkinson et al., 2009) while also noting how domestic cookstoves can make a significant contribution to greenhouse gas reductions (Smith et al., 2000; Smith, 2000; ICMR, 2001; Bruce et al., 2000; Von Schirnding et al., 2002). In response, many improved cookstove and carbon offset programs are encouraging the use of stove designs that mitigate both the health and climate impacts of domestic carbon-based emissions (e.g. Climate Care, 2009; Wallenstein, 2003; Montgomery et al., 2009; Panwar et al., 2009; Edwards et al., 2004). Despite the possibilities for significant development benefits and potential emissions reductions, there is little scholarly analysis of the governance and successful implementation of stoves projects created through carbon finance (although see Mann, 2007; Bumpus, 2009).

3.1. Evolution of carbon markets, methodologies and cookstove inclusion

Although dwarfed by other North–South finance flows, such as those associated with fossil fuel energy production (see Newell et al., 2009), the North-South market for carbon reductions in developing countries has grown from virtually nothing in the late 1990s to over $7 billion dollars a year in 2008. The international primary carbon offset[1] market in the Kyoto Protocol's Clean Development Mechanism (CDM) generates the principal share of this finance transfer (Capoor and Ambrosi, 2009). A parallel voluntary carbon offset (VCO) market, on the other hand, is only a fraction of the size (transacting US$705 million in 2008), although it grew fast around that time, with an 87% increase in transactions between 2007 and 2008 through projects both in developed and developing countries (Hamilton et al., 2009). Although stove projects account for an extremely small percentage of carbon reductions in the global voluntary and compliance markets (see Table 2), this percentage is growing rapidly (GTZ, 2011).

Within the CDM, official small-scale methodologies for cookstove emissions reductions have only recently been included (GTZ, 2011).[2] Key to the potential development of cookstove projects is the reform of the CDM and creation of "Programmes of Activities" (PoA) that enable multiple CDM projects to be included under a policy or programmatic umbrella, in order to scale up emissions reductions with lower CDM transaction costs. The voluntary carbon offset (VCO) market, on the other hand, is able to include technologies and methodologies not acceptable under the CDM registration procedures. The rise in the voluntary market has also meant that interest in cookstove projects as carbon offsets increased as project developers saw a chance for cheap emissions reductions and high quality sustainable development co-benefits that could be communicated to buyers interested in corporate social responsibility marketing (Hamilton et al., 2009; Taiyab, 2006). By the same token, however, the voluntary carbon market has come under considerable criticism because of its unregulated nature and possibilities for false carbon reductions. As a result carbon standards have been developed to assure quality in the market (Bumpus and Liverman, 2008), including the registration of cookstove methodologies and projects to the Gold Standard (The Gold Standard, 2009) (Table 1).

4. Challenges for win-win cookstoves and carbon finance

4.1. Barriers for achieving development objectives in stoves

From a development standpoint, and in order to bring about substantive benefits to recipient households and associated artisan communities, there exist five principal objectives of improved cookstove programs (Simon, 2009, 2010):

- Deliver technologies for which there is (at least latent) demand, and that are compatible with household specific cooking and heating habits, food preferences and domestic architecture. Technologies should also reduce fuel requirements and render the indoor environment less polluted.
- Establish supply chains that maximize the number of households receiving new technologies.
- Disseminated stoves should be durable and supported by periodic monitoring activities in order to discourage early abandonment.
- Improved cookstove programs must ensure that stoves remain affordable for all members of the targeted development community.
- Improved cookstove programs should support pre-existing artisan networks through training courses while also generating new employment opportunities.

There exist a number challenges, however, that may prevent win-win scenario programs from reaching these development standards. The first pre-condition for success is that there is adequate demand for the cooking technologies being promoted. For example results from ongoing research in Bangladesh indicate that while the price of cookstoves is an important factor, in many cases the underlying motivation for change is low (McCann, 2009). The research found that there was only a 70% initial take-up of improved stoves even when devices were offered at zero cost—and

[1] The 'primary' offset market constitutes transactions from newly created credits generated through new projects, whilst the 'secondary' market is based on trading of credits already registered through carbon standards, such as the Kyoto Protocol's Clean Development Mechanism (CDM).

[2] Although there were domestic biogas cooking projects in the CDM, the current methodologies under the CDM are *CDM AMS II.G small-scale* "Efficiency Measures in Thermal Applications of Non-Renewable Biomass", and *AMS-I.E small-scale* "Switch from Non-Renewable Biomass for Thermal Applications by the User".

Table 1
Current projects in pipeline and registered to approved compliance (CDM) and voluntary (Gold Standard VER) carbon markets.

Standard	Projects in pipeline	Scale of project/carbon reductions	Stove Projects registered	Example countries	Projected volume of credits from existing and pipeline projects
CDM	4 (0.08% of total projects in CDM pipeline)	Only small-scale possible	1	Nigeria (registered); Nepal (pipeline), Bangladesh, Mexico, Guatemala (CDM PoA pipeline)	113,100 t/CO2e CERs
Gold Standard VER	9 (18.75% of total projects listed on the Gold Standard)	Large scale possible	3	Uganda, Ghana, Mali (registered); Africa as regional focus (pipeline)	1.1 million t/CO2e VERs

Source: Gold Standard (2010); GTZ (2011); UNEP-Risoe (2010). Figures correct as of March 2010).

this does not take into account people for whom initially adopted stoves later fell into dis-use. Initial demand notwithstanding, we use findings from various local market commercialization-oriented carbon-finance and non-carbon finance pilot studies to review major challenges here.

4.1.1. Markets and lack of supplementary financial provisions

The commercialization of rural stove economies can fundamentally alter pre-existing social relations of stove production for households, fabricators, wholesalers, loan agencies and State agencies. Alterations to pre-existing payment schedules, raw material subsidies and dissemination networks may arise in the context of scalable carbon market approaches (Mann, 2007; Martinot et al., 2002). For many supply chain actors, and particularly those previously operating within small and/or government run programs, the consequences of these transformations are significant. For example, under the Shell Foundation's 'Commercialization of Biomass Fuel and Cooking Devices' (CBFCD) program in Maharashtra, India, many low-income households were unable to experience stove benefits as they were too poor to pay the full price (Simon, 2010). Bumpus (2009) has identified similar findings in China, Kenya and Honduras as commercial stove dissemination approaches have created financial barriers for households and entrepreneurs alike. Although market based approaches may "respond better to user demand, including the production of more durable stoves" (World Bank, 2002b, p5), programs that also strive to achieve greater development equity may also benefit from supplemental financial provisions. Microfinance programs or grants are therefore essential for providing up-front costs to poor households who may otherwise eschew new cookstoves (Bates, 2009). Simon (2009) illustrates how financial coffers within village governing bodies and state development programs can provide an entry into the stove market for artisans lacking start-up capital. Cashflow from carbon investors can also serve as a mechanism to alleviate financial constraints by providing cost offsets to households, or indirectly to artisans, who then pass cost savings on to consumers (Table 2).

4.1.2. Inadequate local support

Based on their research in South Africa, Still and Hancock (2009) found that support from local agencies helps to ensure cooperation between market and civil society actors. Non-profit organizations in particular are crucial intermediaries that can leverage their independent status and longstanding ties to influential village members and political figures by coordinating activities for households, entrepreneurs, local government outlets and financing agencies (Simon, 2010). Without properly implemented marketing campaigns and stove demonstrations, household appreciation for improved cookstove health and environmental benefits may be low and hinder dissemination efforts. Community agencies can improve household stove commitments by organizing follow up technical support activities to fix and maintain failing stoves. In Mexico's Central Highlands, for example, nearby non-profit organizations and university centers played a central role in overseeing lab testing, field validation and community education activities to ensure dissemination of clean and compatible stoves (Bailis et al., 2009). While a major concern for large-scale improved cookstove dissemination and market scale-up is inadequate supply capacity (Bhogle, 2009), local agencies are shown to assist entrepreneurs and increase supply chain output by coordinating financial transactions with loan-bearing institutions in order to assist stove enterprises (Simon, 2009).

4.1.3. Market opportunism

Decentralized governance and active participation by local institutions greatly increases the likelihood of locally sensitive development. And yet it would be naïve to romanticize the behavior of community level actors and ignore local hierarchies,

Table 2
Barriers for achieving development benefits in ICS projects.

Barrier	Details	Examples
Lack of supplementary financial provisions	Achieving equitable development – that is, bringing health benefits to poor households and employment opportunities to diverse artisan enterprises – is hindered in the absence of ready supplementary financial provisions such as micro-finance, no/low interest loans and direct/indirect subsidies.	Mann (2007); Martinot et al. (2002); Feldman (2009); Bhogle (2009); Bailis et al. (2009); Simon (2009).
Inadequate local support	The absence of strong local institutional support can hinder important educational, training, and maintenance activities, and also impede efforts to increase supply chain capacity, adapt local stove economies to commercialization and improve investor confidence.	Avis (2004); Bumpus (2005); Still and Hancock (2009); Bailis et al. (2009); Simon (2010).
Market opportunism	Inadequate regulations and enforcement of market transactions can lead to opportunism along supply chains and uneven distribution of development benefits.	Simon (2009, 2010).
Rigid stove design capabilities	Scaled-up stove dissemination, specified carbon reduction performance requirements, and standardized emissions inventory verification procedures can limit the ability of programs to address heterogeneous household characteristics and needs.	Hanbar and Karve (2002); Khushk et al. (2005); Simon (2010).

collusive relations and patterns of opportunistic behavior that plague many development programs (Corbridge and Kumar, 2002; Jeffrey, 2002). Avarice and corruption are notable in improved cookstove projects receiving investment money from external sources (Ribot, 2004; Bailis et al., 2009). Demands for local accountability, however, particularly from coordinating agencies, have increased over the past decade (Nalinakumari and Maclean, 2005), and within carbon finance, there is a premium placed on good governance in the generation and accounting of carbon offsets (Bumpus and Liverman, 2008; Bumpus, 2011). Still, it has been shown that the transmission of money within improved cookstove projects may be routed through channels of nepotism, cronyism, and political reparation. With little oversight or enforcement, development finance networks may run closely parallel to familial ties and remunerative relationships of financial tribute and political patronage (Simon, 2009). A fine balance should be struck by implementing rules and enforcement mechanisms that assuage local accountability concerns for investors by reigning in corruption but that do not stifle commercial entrepreneurship.

4.1.4. Rigid stove design capabilities

The delivery of suitable household cooking technologies necessitates accounting for diverse regional and domestic needs (Karve, 2007). For example, metallic cookstoves installed in coastal regions have been shown to suffer from the effects of rapid corrosion, while some chimney types are incompatible with regionally prevalent roofing materials or prevailing wind patterns (Khushk et al., 2005; Adler, 2010). Bumpus (2009) shows that in one case carbon finance stipulations on metallic stove-types exposed scale-up to international metal price volatility, leading to local high prices, the need for local NGOs to absorb the higher costs, and an overall difficulty in achieving scalable climate–development benefits. Design innovation restrictions and rigid fabrication specifications emanating from scientific institutes, stove fabrication centers and government agencies can hinder flexible technology production schemes. This was the case in India under the National Program on Improved Cookstoves, when Cookstove Approval Committees mandated strict performance characteristics that became instantiated within regional stove models (Rehman and Malhotra, 2004; Simon, 2010). Inadequate assessment of household stove preferences led many households to discard stove models within a matter of months (Hanbar and Karve, 2002; Kishore and Ramana, 2002). Quite differently, Rollinde (2009) notes how recent programs in the Indian states of Gujarat and Karnataka were successful due to diverse product lines, decentralized procurement of stoves, and ongoing collaboration with local agencies to refine specific design qualities.

Concern over whether stoves match individual household needs (e.g. Bailis et al., 2009) resonates particularly strongly in the context of carbon markets requiring (a) high volume projects required to lower overall transaction costs and generate sufficient greenhouse gas reductions, (b) technologies with specified carbon reduction performance requirements, and (c) standardized emissions inventories and reduction calculations in order to accurately determine large scale greenhouse gas emission offsets. These production and dissemination imperatives raise the possibility for high volume installations that oversimplify a heterogeneous consumer base. Adaptive production capacities can allow fabricators to meet the needs of stove users from varying geographies, and with diverse housing types, cooking practices and fuel requirements. Carbon finance programs may need to work with existing procurement and distribution structures to develop a diverse inventory of stove models with sufficient and verifiable emissions reduction capacities.

4.2. Barriers for reducing greenhouse gas emissions

Although improved stoves are able to reduce net greenhouse gas emissions, there are a number of technical and policy barriers that can prevent the rollout of cookstoves from contributing to greenhouse gas reductions (Table 3).

4.2.1. Measurement and verification

As Johnson et al. (2010) point out, measurement and verification of emissions reductions in households spread over wide distances are much more complex than, for example, calculating industrial emissions from point-sources such as smoke stacks.

Table 3
Barriers for reducing GHG emissions in ICS projects.

Barrier	Details	Examples
Measurement and verification	Decentralized nature of cookstove projects requires strong local governance institutions and structures in order to measure, monitor and verify emissions adequately, which is expensive.	Johnson et al. (2010); Martinot et al. (2002).
Inclusion of non-CO2 gases	Some carbon finance methodologies include non-CO2 gases thereby raising potential finance opportunities. Accounting for these gases is based on emissions factors generated from laboratory tests, some with high levels of uncertainty in their climate impact (for example, black carbon)	Johnson et al. (2010); Zhang et al. (2000); Chen et al. (2009); Grieshop et al. (2009).
Calculating non-renewable biomass	Non-renewable biomass (NRB) used as fuelwood is geographically patchy, and depends on site-specific, and multiple spatiotemporal factors, including land use change, accessibility restrictions, consumption patterns, and cultural bases. Some projects use GIS to measure NRB, but most rely on local analyses and statistical sampling due to low resolution of GIS methodologies.	Arnold et al. (2006); Top et al. (2004); Mahapatra and Mitchell (1999); Masera et al. (2005); Ghilardi et al. (2009).
Leakage	Savings of NRB in one area may lead to increases in use of NRB in another area not covered by the project boundary. Illegal harvesting of wood is also hard to detect. Leakage is more paramount in countries without comprehensive forest/carbon management plans and may be exacerbated by policy, markets, migration, and other economic trends.	Bass et al. (2000); GTZ (2011); Schwarze et al. (2002).
Longevity of carbon finance and climate policy	Investment and longevity of new carbon finance projects is affected by factors at multiple scales including regional/international targets for emissions reductions and inclusion of offsets; economic conditions in developed countries; eligibility of cookstove projects into carbon trading schemes.	Purdon (2008), Bell and Drexhage (2005) and Wara and Victor (2008).

Stoves vary widely in their ability to reduce greenhouse gas emissions because of variations in non-renewable biomass (NRB), types of biomass, different stove technology, and differential inter-cultural and inter-household uses of stoves. For CO2 and methane reductions (allowed under Kyoto) Johnson et al. (2010) found Mexican Pastari stoves to reduce 3.1 tCO2e home^{-1} year^{-1} (95% CI $\pm$ 26%), while other stove types, such as Honduran *ecofogones* have been found to create reductions varying according to stove use, ranging from 0.85 tCO2e to 3.45 tCO2e per year for domestic and commercial use (i.e. cooking tortillas), respectively (Bumpus, 2009). Direct measurements in households often require the installation of vented hoods, which can be invasive and costly, and typically only provide short-term estimates of emissions from a single stove use event (Bumpus, 2009, p2456). Related to this barrier is the availability of local skills and the application of new technologies that create challenges for meeting the monitoring and verification needs of decentralized stove projects (Martinot et al., 2002). Fuel consumption is also a key factor in determining emissions reductions through monitoring. Fuel consumed by households using biomass stoves usually comes from informal sectors, non-commercial or locally purchased sources, and as a result poses methodological and logistical problems in tracking fuel consumption; a key element in greenhouse gas accounting for cookstoves (Johnson et al., 2010).

4.2.2. Inclusion of non-CO2 gases

Current CDM stove methodologies state that only CO_2 can be certified for emissions credits, despite the fact that the Kyoto Protocol allows six greenhouse gases to be eligible for emissions reduction credits under the CDM. The Gold Standard (GS) stove methodology, on the other hand, allows the crediting of nitrous oxide (N_2O) and methane (CH_4) emissions reductions (GTZ, 2011) although they rely on emissions factors that can lead to variation in estimates of up to 43% (Johnson et al., 2010). In comparison to the CDM, the GS methodology allows a more detailed understanding of local biomass conditions, using a measured subsample of homes and quantitative estimates for fuel consumption and offset generation. Even so, both methodologies have been shown to include significant errors in the estimation of carbon offsets (Johnson et al., 2010) creating potential problems for their inclusion in markets, unless conservative estimates are employed. The differences noted in the CDM and GS methodologies above are important considerations for the use of carbon finance for stove projects. Due to its inclusion of N_2O and CH_4, the GS methodology can create more attractive financial returns because of their higher global warming potential. The inclusion of these gases is also important because they are not sequestered back through biomass uptake in areas of renewable biomass (therefore obviating the need for non-renewable biomass in carbon accounting) (Smith, 2000). The possible inclusion of black carbon reductions as creditable global warming mitigation could also raise the carbon offset credits generated by a project (Grieshop et al., 2010).

4.2.3. Calculating non-renewable biomass and attributing stove use to deforestation

The use of non-renewable biomass is important for cookstove projects to access carbon finance. Carbon reduction methodologies for cookstoves must include indicators that enable project developers to prove the proportion of biomass used for cooking which is obtained from non-renewable sources (known as 'fraction of non-renewable biomass'; fNRB). Project developers use independent indicators (such as increasing trends in fuelwood scarcity, and increased time spent gathering wood) to assert fNRB in project documentation. The distinction between fNRB and renewable biomass is difficult in practice because it involves land changes over large time intervals (EU, 2007) and relies on basic assumptions of renewability which some have shown to be flawed (Searchinger et al., 2009).

Due to the need to scale stoves over space and reduce transaction costs, fNRB indicators are necessarily proxy calculations and not absolute measurements. This creates significant barriers to the carbon inclusion of stoves because of calculation uncertainty. For example, Johnson et al. (2010) show the fraction of NRB contributed to 72% of the uncertainty in carbon savings for some cookstove projects. In addition, current spatial models for calculating the fraction of NRB harvested at national levels lacks sufficient resolution to characterize fuelwood consumption, which is often highly variable between communities (Johnson et al., 2010; Ghilardi et al., 2009). Other models estimate fuelwood supply and demand by defining accessible areas to users and modeling land use based on geographical information system cost-distance maps. These may reduce uncertainty by targeting specific land cover affected by the project (Ghilardi et al., 2009), but may also increase transaction costs, affecting the delicate balance between strict environmental integrity of individual stove emissions reductions and scalability of project and *overall* net reductions. As Johnson et al. (2010) show, however, a reduction in uncertainty should more than compensate for investments in more accurate monitoring; particularly increasingly refined and cost-efficient methodologies developed by organizations such as the Spatial Informatics Group.

Alongside fNRB debates, attributing stove use to deforestation and thus the depletion of an important carbon sink remains controversial, particularly given considerable uncertainty, concerning the relationship between domestic stove use, biomass collection and forest loss (Leach and Mearns, 1988; Nagothu, 2001; Pandey, 2002; United Nations, 2000). Fuelwood shortages are often attributed to changing land ownership and access rights due to forest conservation policies, industrial agriculture and land clearing, and not necessarily rampant wood gathering activities (Saberwal et al., 2001; Bhatt and Sachan, 2004; United Nations, 1997).

4.2.4. Leakage

Leakage – whereby emissions increase outside the project boundary as a result of the project – is a potential barrier to emissions reductions in any carbon offset program. If the savings of NRB in the project area result in an increase in consumption of NRB in another – for example, if the NRB saved is diverted to non-project households who were previously using renewable biomass – then the greenhouse gas reductions must be adjusted to account for this leakage (GTZ, 2011; Whitman and Lehmann, 2009). In addition, a form of leakage can also occur if traditional stoves continue to operate alongside improved varieties. This is a significant problem in attaining accurate greenhouse gas reductions because three-stone fires are constructed extremely easily and are often used when improved cookstoves fail at the end of their life span. Although the UN methodologies have tried to account for this through monitoring, it is accepted that the non-use of replaced stoves or cooking systems cannot be guaranteed in every project scenario (GTZ, 2011).

4.2.5. Longevity of stove projects through carbon markets and climate change policy

Another barrier to greenhouse gas reductions through stove based carbon finance is the volatility and uncertainty in international climate change policy that includes cookstoves as eligible offsets. While carbon finance mechanisms developed in the North may provide considerable finance to the South for cookstove projects, they are also dictated by political decisions and may change or expire at scales that are dislocated from stove implementation and users. Specific governance and financing issues such as business models for carbon stove diffusion that incorporate blended finance between donor funds and carbon finance, may be written in and out of carbon finance policy, with significant ramifications for projects on the ground. If such models explicitly rely on carbon finance (which is necessary to prove additionality for the project), then stove development outcomes are at the whim of northern carbon markets and policy decisions. This potentially opens risks associated with project developer investment criteria that are linked to both regulated market policy (post-Kyoto regulation, or emerging US regional regulation, for example), or voluntary carbon markets that rely on more ethereal concepts of corporate social responsibility and green marketing to sustain buyers of credits (Liverman, 2009).

5. Opportunities for win-win in cookstoves and carbon finance

Despite numerous barriers to achieving win-win outcomes, cookstoves form an important environment–development interface technology. As a result, opportunities exist for the integration of carbon finance into cookstove projects. Alongside technologies such as biogas digesters, cookstoves are one of the few explicit 'development interventions' that are now experiencing an inflow of carbon finance (Climate Care, 2007; Limmeechokchai and Chawana, 2007; World Bank, 2009). By providing funds to generate, implement and maintain stoves, carbon finance creates the potential to generate significant development benefits and emissions reductions that are mutually supportive.

5.1. Improving public health and carbon finance for stoves

Improved stoves can dramatically improve indoor air quality whilst simultaneously reducing energy poverty and also forest loss where the fuel saved is NRB. The incomplete combustion of carbon-based biomass fuels exposes household members to harmful levels of particulate matter, carbon monoxide, nitrogen oxides and other pollutants. Social benefits exist in the form of improved health and reduced time required to obtain biomass for household occupants (Bruce et al., 2000; Hanbar and Karve, 2002; Von Schirnding et al., 2002). The physical use of stoves means that carbon and development benefits are integral to each other: as the new, cleaner stove is used, carbon reductions (against a baseline) are created. This "integrated carbon-development" (Bumpus, 2009) characteristic differentiates cookstoves from the vast majority of carbon offset projects that either have co-benefits added on to existing projects, or that by-pass local development entirely (Olsen and Fenhann, 2008a,b). The role of such 'high sustainable development' offsets comes at a time when there is a "rush to quality" in the carbon market because of low carbon prices (World Bank, 2009), and because of premiums being paid for credits with co-benefits (Bumpus and Cole, 2010). Market participants note that the 'social value' associated with corollary development benefits is an explicit advantage in the carbon market (JPMCC, 2011). Several specific win-win outcomes can be seen as a result of this new interface.

5.2. Reducing deforestation and carbon finance for stoves

Carbon offset methodologies specify the fraction of non-renewable biomass using indicators such as increased time spent or distance traveled to gather fuel-wood, increased transport of fuel wood to markets, changes in types of fuel wood use and trends in fuel wood prices that indicate scarcity (GTZ, 2011). Where non-renewable biomass is used for cooking (as is the case in many areas of stove use), improvements in efficient biomass burning bring carbon dioxide emissions reductions through reductions in consumption of non-renewable biomass, contributing to multiple benefits associated with forest conservation, energy expenditures and time spent gathering wood from increasingly distant locales (Bhattacharya and Salam, 2002; Limmeechokchai and Chawana, 2007; Mann, 2007; Sagar and Kartha, 2007).

5.3. Scale up, supporting existing local economies and effective governance

Although debate exists concerning precise levels of stove-based greenhouse gas reductions (see Johnson et al., 2010), the low amount of emissions reduction per unit means that it is in the interests of both development and carbon reduction practitioners to scale-up stove use through innovative financing. This includes improving capacity of local stove makers by providing capital for commercialization of artisanal stove producers in communities. Efforts to attain carbon project objectives has been hindered, for various technologies, by the inability of external agencies to forge strong partnerships with local organizations in developing world contexts, especially outside of the major developing economies, such as China, India, Mexico, Brazil (Bumpus, 2005). Local institutional support is also required to convey preexisting market relationships and idiosyncrasies to investment agencies and other external entities. Active involvement by local agencies resonates well with carbon investors, as financiers are averse to projects lacking stable and knowledgeable interlocutors familiar with the cultural idiom of target areas. Win-win outcomes from the carbon financier's point of view arise under the presence and expertise of *in situ* development NGOs and companies capable of overseeing development affairs. Meanwhile, beneficial outcomes for artisanal communities and local NGOs emerge as financing scale-up generates employment opportunities, and valuable international carbon market experiences are leveraged in order to secure institutional leadership roles on subsequent local development projects (Bumpus, 2011). In the context of cookstoves, carbon finance, should therefore *enable* local economic development practices, rather than *hinder* them through the stipulation of high carbon reduction or locally inappropriate technologies and governance structures. Indeed, additionality can only be claimed when carbon finance helps scale up local stove production beyond foreseeable capacity, assisting local entrepreneurs and development NGOs to strengthen local economies and overall stove provision.

5.4. Stove use longevity and carbon finance

The evolution of the carbon markets means that credible offsets must be calculated through reputable standards. This necessarily increases transaction costs (for example, the need to pay third party verifiers to assure carbon reductions), but also assures that stoves are used over time, repaired when necessary and monitored for every successive round of emissions reduction claims. A key problem for sustainable stove uptake has been the inability (or unwillingness) of donors to follow up on stove use over time, thus allowing stoves to fall into disrepair or non-use. Carbon finance creates financial incentives to maintain stoves over time and monitor their use in order to generate new carbon credits (Bumpus, 2009). As a result, carbon finance may actively support longevity in stove projects. For example, in the Central Highlands of Mexico, improved carbon dioxide projects included three post-installation household visits. Though costly and time intensive, surveys by local NGOs indicate that follow up visits increased long term adoption rates from 50% to 85% (Troncoso et al., 2007; Bailis et al., 2009). The inclusion of CH_4 and N_2O in the Gold Standard methodology, furthermore, requires additional efforts in monitoring the use of the stove if they are to be included in carbon credit generation (GTZ, 2011). Given the high global warming potentials of these gases, and, therefore, profitability in the carbon market, there is a strong incentive for effective follow-up on stove use, and its associated development benefits.

6. Three early examples of stove dissemination projects using carbon finance

The section below uses concise project summaries to introduce and describe some of the accomplishments, implications and problems associated with three ongoing carbon-financed stove distribution projects (see also Table 4). Each summary is based on newly released reports and communication with on and off-site project employees.

6.1. Project summary—Qori Q'oncha Project

In the poor mountainous region of the Peruvian Andes, the Qori Q'oncha Project is overseen by the Switzerland based non-profit *myclimate* and the French-Peruvian based social enterprise Microsol. Microsol functions as the project owner and developer, while myclimate supports development of the carbon process by operating between credit buyers and program activities. The project services three districts, each with its own local project participant and unique stove model and diffusion strategy (Myclimate and Microsol, 2010). Most stoves are made out of adobe and emphasize efficient fuel combustion for cooking and heating. Many also use chimneys to remove smoke from the cooking environment. Nearly 30,000 improves stoves were distributed during the period 2008–2010, and scale up is expected to deliver approximately 260,000 stoves by project completion. Based on program stove diffusion levels between 2008 and 2010, 168 291 tCO2-eq are projected to be reduced over the next 7 years (Myclimate and Microsol, 2010).

According to project managers at Microsol, inclusion of carbon finance has made scaling up stove distribution considerably easier, thus generating greater development dividends within the project area. Stove improvements and market advancements typically proceed incrementally. Thus, anticipated revenues stemming from carbon financing help to sustain both market growth and cooking technology improvements. As one Qori Q'oncha Project manager put it, "The capacity to anticipate revenues in the medium and long term, allows [local parties] to plan activities of follow-up, maintenance, repairing and project extension" (Microsol, 2011). Because cookstoves and stove user services are developed using a trial and error approach, progressive technology advancements, spare parts diffusion schemes and post-sale services have profited from sustained carbon financing.

The participation of three local organizations – Sembrando, ADRA Perú, ProPerú – has been crucial for scaling up cookstove installations in each district. These local actors inform communities about project activity details, coordinate supply chain capacity building, perform kitchen emission tests and carry out stove user surveys. Similarly, a diverse lineup of cooking technologies has helped promote continuous stove use and maintain mutually supported benefits at the climate–development interface (Myclimate and Microsol, 2010). Throughout the scale up process, the Qori Q'oncha Project ensures that activities "are open and not favoring a unique stove model." According to employees, diverse stove options generate "incentive for local or household stove production that has shown to be much more sustainable than imported stoves" (Microsol, 2011).

Despite these development benefits, calculating and maintaining carbon emissions have raised some challenges. According to Microsol, the most significant difficulties include lack of local expertise for (a) monitoring emission reductions and (b) identifying and managing efficient supply chain transactions. In many cases, these problems are overcome with extensive capacity building activities and a general simplification of technical and managerial processes. Yet frequently, according to project staff members, "practitioner workshops and information raising activities are scarce or inaccessible" (Microsol, 2011). Problems associated with project leakage are minimal under the Qori Q'oncha Project, as only the transport of spare parts into project areas is considered a source of difficult-to-quantify additional greenhouse gas emissions. Determining fNRB has been much more challenging, however, as data on forest type and usage are limited in many areas. In addition, familial access to forest resources varies over time and space making it very difficult to assess forest use (Myclimate and Microsol, 2010).

6.2. Project summary—Ugastove Project

JPMorgan Climate Care (JPMCC) developed the first decentralized scale up of improved cookstove distribution under the Gold Standard VER in Uganda by expanding activities of the local 'Ugastove' stove company. Ugastove manufactures and disseminates three types of stoves: charcoal for domestic and restaurant use, residential wood stoves, and institutional wood stoves. Charcoal stoves are distributed in urban areas; institutional wood stoves in urban and peri-urban areas; and domestic wood stoves in rural areas. Given that the Ugastove business was not financially solvent, carbon finance was identified as the only feasible method for up-scaling activities. With carbon finance included, projected stove sales total nearly 180,000 over seven years, and produce a total projected emissions reduction of nearly 600,000 tCO2e, assuming a 3-year life span for each cookstove and 92% non-renewable biomass for charcoal use. Internal analysis shows that the project is additional: families and institutions would continue to use inefficient cookstoves in the absence of improved stove availability.

According to program reports, the Ugastove project contributes to forest protection, indoor air quality, improved livelihoods for impoverished communities, increased employment opportunities, and institutional and technological self-reliance for local stove manufacturers (JPMCC and CEIHD, 2009). The Ugastoves network continues to expand with the help of carbon finance by promoting stove affordability and longevity. Carbon finance provides a basis for maintaining a professional commercial relationship between the user and disseminators, while also introducing an affordable price, a quality guarantee and a warranty system. According to JPMCC, this finance structure rewards competent business management and marketing practices, as revenues only flow once strict auditing has proven actual usage of the product. This is a fundamental reversal of the dependency culture associated with short-term development aid financing (JPMCC, 2011).

One potential danger of scale up is the suppression of other similar or competing enterprises as a result of external financial injections and cost-free technical support associated with the Ugastove project. According to JPMCC, however, the Ugastove project has effectively demonstrated carbon market viability. In practice there are now a host of other stove producers on the streets of Kampala, several of which have other carbon finance initiatives working with them (JPMCC, 2011). In order to facilitate program enrollment by other stove manufacturers, the "Ugastoves" in 2010 no longer functioned as a single business but rather as a wide network of separate businesses, open for any capable body to join and attract carbon finance.

The Ugastove project has avoided emission reduction calculation difficulties primarily due to increased communication with local project proponents. Outreach to stove manufacturers and users involves explaining how carbon financing can facilitate the delivery of development benefits associated with improved cookstove installation. However, they also make clear that accurately calculating and verifying emission reductions through dedicated stove use is a prerequisite to receiving carbon finance (JPMCC and CEIHD, 2009). All parties are thus encouraged to contribute to the calculation and maintenance of carbon emissions in a reliable and transparent manner. With respect to the sometimes confounding process of determining non-renewable biomass levels, simplified methodologies under the CDM and VER markets have required calculating just the ratio of un-managed to demonstrably managed wood-fuel resources.

6.3. Project summary—New Lao Stove Project

The New Lao Stove Project has distributed more than 1.2 million stoves over 8 years, mainly to households in urban and peri-urban areas of Cambodia, producing carbon offsets in excess of 1.1 million -tCO2e to date. The typical New Lao Stove consumes around 20% less fuelwood and charcoal than the Traditional Lao Stove. The project was implemented by GERES under the larger Cambodian Fuelwood Saving Project, which ran from 1997 to 2006 with the goal of reducing wood consumption and protecting forest resources. At the end of this project, GERES decided to pursue carbon finance to achieve large-scale dissemination of the New Lao Stove (GERES, 2011).

Overall the process of applying carbon finance to the New Lao Stove Project has been positive from the perspective of local development outputs. According to project managers, carbon finance allows not only more stoves to be distributed but also increases the quality standards for cookstoves. One of the main benefits of carbon finance has been the development of an organized stove production sector in Cambodia that consolidates producers and distributors under a single production association—the Improved Cookstove Producers and Distributors Association (GERES, 2011).

According to these same employees, carbon finance has provided a number of advantages over the donor-funding model. First, donor funding typically involves provisioning a proportion of funding upfront, and withholding complete payments until particular pre-specified project parameters are met. This approach is often inflexible and results in managers simply signing-off on project accomplishments rather than genuinely challenging the project developer on the basis of professional skepticism (GERES, 2011). In contrast, the process of verification (periodic audits required to access carbon finance) has meant that quality standards are maintained over time. Second, recipients of donor funding are generally identified according to donor priorities (countries, project types, etc.); it is hard for new players to enter into such arrangements, whereas carbon finance has the potential to be more egalitarian in terms of project selection. Third, the timeframe for donor funding is typically 3–5 years. Carbon finance has longer funding horizons that are more appropriate for developing sustainable project interventions (GERES, 2011).

Some difficulties were encountered in accessing carbon finance for the New Lao Stove project. In terms of calculations, the abstract concept of non-renewable biomass has been difficult to quantify on the ground, resulting in arduous accounting practices. Moreover, monitoring of the project necessitates reconciling the need for international data collection standards with the reality of working with stove producers who tare often times illiterate and typically do not keep written records. Carbon offset revenue sharing is also an issue for this type of project, and there is a need for further clarity on the matter of credit ownership (GERES, 2011).

According to project employees, the large scale and geographic distribution of the project also presents challenges. The project utilizes existing stove production networks in Cambodia, and thus requires re-training artisans to manufacture New Lao Stove models. The decentralized nature of the stove production network in Cambodia has also presented significant challenges for monitoring production and sales data and the movement of stoves along the supply chain. The consolidated production and distribution network not withstanding, there currently exists more than 30 New Lao Stove producers spread across nine provinces in Cambodia (GERES, 2011). Importantly, however, this dispersed network can be productively leveraged to promote stove designs that are adapted to particular geographic contexts and thus sustain desirable mutually supported benefits (Table 4).

Table 4
Details for three existing projects.

Project	Qori Q'oncha Project	Ugastove Project	New Lao Stove Project
Program oversight	Myclimate, Microsol, and three local NGOs—Sembrando, ADRA Perú, ProPerú	JP Morgan ClimateCare (JPMCC), Centre for Entrepreneurship in International Health and Development (CEIHD)	GERES (Groupe Energies Renouvelables, Environnement et Solidarités)
Crediting period	7 years (renewable three times)	7 years (renewable three times)	10 years
Location	Peru	Uganda	Cambodia
Targeted market	Poor households with emphasis on indigenous, rural communities in three districts	Urban household and restaurant use; peri-urban and rural residential and institutions (e.g. schools and hospitals)	Primarily urban and peri-urban households that use charcoal for cooking. Larger stove models are used by restaurants.
Local governance structure	Three local project partners coordinate stove testing, emissions recording, household survey and supply chain management activities.	Implementation partners (Ugastoves) run local network of stove manufacturers and administer revenues from credits	GERES is responsible for project implementation. Access to credit facilities and stove pricing structure managed by stove producers and distributors association.
Number of stoves disseminated	Projected: 260,000 over 7 years. 29,069 (2008-2010)	Projected: nearly 180,000 over 7 years	More than 1.2 million since 2003.
Estimated CO2 (ton-equiv)	168,291 tCO2e (projected over 7 years)	599,307 tCO2e (assumed 3 year life of stove, implementation over 7 years)	2,031,865 tCO2e (expected over 10 year project lifetime)
Proposed principal development benefits	Forest protection through reduced non-renewable firewood collection. Household health benefits in cooking environment. Growth of local artisan stove and parts markets. Affordable cooking technologies.	Economic growth of local stove markets. Affordable to as many houses as possible. Technical self-reliance. Household health and economic benefits from more efficient wood burning. Reduced local/national deforestation.	Large-scale distribution of efficient, clean-burning cookstoves. Improvement in quality standards for cookstoves. Consolidate producers and distributors to manage pricing and access to credit. Access to a more flexible and long-term financing stream.

7. Discussion: cookstoves and win-win outcomes at the climate–development interface

The Peru, Uganda and Cambodia case studies above highlight how previously independent debates on indoor air pollution and greenhouse gas emissions from stoves may be productively viewed as interdependent fields of research and practice that contribute to the development of new carbon offset methodologies. The use of carbon finance for improved cookstove programs presents an opportunity to scale-up development benefits associated with the use of improved cooking technologies while also reducing greenhouse gas emissions. In this way, the convergence of climate mitigation and stove development programs via carbon financing can generate benefits that are at once intensive and extensive. Improving air quality in the domestic sphere will bring immediate assistance to many thousands, even millions, of rural households. Reducing greenhouse gas emissions from traditional stoves will bring widespread benefits by contributing, albeit modestly, to the mitigation of global climate change.

7.1. Mutually supported benefits, impediments and the importance of sustained stove use

Moreover, this essay has described the mutual benefits derived from pursuing each set of objectives within a single integrated climate–development framework. Along with the obvious development and environmental co-benefits achieved through improved stove technology use, stove compatibility and maintenance issues may be improved through monitoring required by carbon finance—a noted deficiency in many conventional improved cookstove development projects. Carbon markets can, therefore, provide a forum for generating and leveraging financial incentives to maintain stoves, monitor them over time and support local users.

A number of challenges remain, however, that may inhibit efforts to actualize win-win outcomes. Some of these challenges can be seen as mutually supported impediments. Mutually supported impediments occur when requirements for achieving one set of project objectives directly compromises progress towards another set of objectives. Since climate and development are integrated co-benefits of improved cookstove use, failure on one front can result in decreased rates of success on the other. Thus, in the case of improved cookstove programs, mutually supported impediments arise when the integrity of stoves, and their likelihood of remaining in use, is compromised. For example, improved cookstove programs using carbon financing must be large enough to meet net carbon savings investment criteria and so require scaling by maximizing the regional distribution of improved cooking devices. They must also contain a level of technological spatiotemporal standardization in order to generate certifiable and cost effective emissions measurements. These program requirements are susceptible to "abstracting" diverse development needs that are influenced by different household level cooking preferences, affordable fuel alternatives, architectural constraints and local environmental conditions. Rigid emissions reduction verification and accounting measurements and scaled-up distribution frameworks may be at odds with more nimble program approaches for meeting the needs of a heterogeneous development community (see Table 5).

7.2. Defining win-win and the need to articulate equitable development targets

Alongside mutually supported impediments generated by inappropriate technology installations, commercially oriented improved cookstove projects may generate uneven development outcomes in the absence of adequate supplemental financial provisions for poorer households, local institutional support and finance distribution enforcement mechanisms. It is here where potential ethical tensions exist for carbon financed improved cookstove distribution and win-win scenarios more generally. Achieving win-win status in the form of overall greenhouse gas emissions and indoor air pollution emissions reductions may not *explicitly* require meeting other important development objectives such as increasing access to clean technologies for the very poorest households.

Key to this discussion, as we have noted in this essay, is defining what counts as a substantive "win". If a development "win" does not require ensuring access to improved cookstoves for the very poorest, then win-win outcomes can be achieved through commercialization methodologies irrespective of how equitably development benefits are distributed. In this way, the *privileging* of climate benefits, without equal levels of commitment to development benefits, could lead to outcomes that fail to address the health needs of millions of *under-privileged* households. Likewise, such provision may not be afforded to all local populations with

Table 5
Mutually supported benefits and impediments for carbon financed cookstoves.

	Development	Climate
Mutually supported benefits	1. GHGs emission reductions from improved stoves coincide with decrease in harmful indoor air pollutants.	1. Through technology design attributes, smoke abatement and curtailment of other pollutants occurs together with GHG emissions reductions.
	2. Emissions accounting through monitoring and ex-post verification can double as follow-up maintenance visits. Routine up-keep extends stove use longevity. Consistent stove use increases scope of development benefits.	2. Dedicated and long-lasting stove use is required to optimize size and duration of GHG emissions reductions. Carbon financiers and monitoring agencies will view dependable emission reduction favorably.
	3. Carbon financing can provide partial stove cost offsets for households and/or commercialization of local stove production, thus lowering stove purchase price and providing market access to poorer households. Affordable technologies are required to increase distribution of household benefits.	3. Increased use of efficient stoves reduces overall GHG emissions and also consumption of non-renewable biomass (decreases deforestation—thus increasing levels of forest carbon sequestration).
Mutually supported impediment	1. Distribution scale-up under carbon financing is pursued in order to generate sufficient GHG reductions and implement straightforward emissions accounting procedures—both of which are required to attract investors. Distribution economies of scale and technology standardization may be ill equipped to satisfy diverse household requirements, leading to the allocation of inappropriate stoves and to continued levels of indoor air pollution.	1. Development objectives requiring nimble stove distribution and household sensitive technology applications may be impeded under distribution scale-up. Consequently, the distribution of stoves that are incompatible with household level practices can decrease the rate and longevity of household stove use, thus dampening overall levels of GHG emissions reductions.

potential to engage the project. For example, carbon financed improved cookstove projects cannot occur in areas where renewable biomass is used (or where the fraction of non-renewable biomass is difficult to assert), even though the use of improved cookstoves may still be important for family member health in these areas. Moreover, increasing the use of carbon finance to support improved cookstove dissemination may open up stove programs to spatiotemporal variations in funding due to volatile carbon markets that depend on regulations operating at dislocated scales, far removed from local needs. Win-win can be defined in many ways: and issues of equity issues should be central to these discussions (Liverman and Boyd, 2008). How we define success in each program area – even where they are mutually supported – will ultimately be reflected in key programmatic and investment decisions and, ultimately, in the distribution of project benefits.

Invariably, critics will argue, win-win rhetoric is inaccurate: development always produces winners and losers. Worse yet, trumpeting co-benefits can serve to mask development failures and maneuver proposed programs past discontented communities. Our purpose here has not been to wholly validate or discredit these assertions (despite our sympathy for such claims), but rather to present a nuanced analysis of factors that both prevent and enable widespread and more equitable cookstove development outcomes alongside modest greenhouse gas reductions. We have shown that in the case of improved cookstove carbon financing, climate–development benefits can be productively viewed as integrated and mutually supportive. The very factors that promote improved indoor development benefits – most notably, dedicated and long-lasting improved cookstove usership – are also required to maintain reliable greenhouse gas reductions and attract carbon financing.

8. Conclusion

The mutually supported benefits structure of carbon financed improved cookstove projects suggests the importance of employing a rather more nuanced analysis of win-win scenarios that avoids labeling them as *de facto* ‘‘win-lose’’. However, the pathway to automatic win-win status is not always clear. Those who optimistically prognosticate win-win outcomes, particularly during program naissance, need to acknowledge the innumerable challenges and pitfalls requiring navigation—problems that can plague improved cookstove programs under carbon financing, resulting in locally undesirable and uneven development outcomes. The challenge for future carbon financed improved cookstove projects will be to use inherent symbioses between each arena as leverage points for overcoming mutually supported impediments and other challenges associated with commercialization and carbon financing. Doing so can instill confidence in collaboration between program managers, financiers and local institutions to overcome these challenges and create global change through cross-scale connections. Indeed, the three case studies described in this essay – Peru, Uganda and Cambodia – illustrate how the climate–development interface can be carefully navigated using carbon finance.

Achieving substantive win-win conditions will require further scholarly and practical engagement to tackle the many outstanding challenges and uncertainties reviewed in this essay. Firstly, the connection of Southern communities to carbon finance, financiers and, ultimately, carbon emitters buying carbon credits, opens up important possibilities for scholars to examine stoves by engaging scholarship on the scalar politics of climate mitigation (Bulkeley and Betsill, 2005), capital flows for ‘clean development’ (Newell et al., 2009; Bumpus, 2011), and long standing debates on market based development intervention (Bailis et al., 2009; Simon, 2009, 2010). Nuanced understandings of how global greenhouse gas mitigation and stove development policies proceed on the ground are required to better elucidate ‘who wins’ and under what conditions (Forsyth, 2007). Secondly, additional grounded assessments of carbon stove projects will be required to further explicate specific programmatic, institutional and intra-partnership conditions that hinder and enable acceptable carbon financing and scale up outcomes for individual households and investors alike. Thirdly, further attention must be given to the mutually supported benefits/impediments raised in this essay. How can scale-up and emissions accounting standardization requirements be adapted to remain nimble in light of diverse household needs? And what is the best method for articulating and leveraging mutually supported benefits within stakeholder communities in order to overcome program challenges? Fourthly, there remain a number of standing debates, such as greenhouse gas reduction possibilities associated with black carbon and also non-renewable biomass sources that, once resolved, will undoubtedly refine carbon financing and enhance support for improved cookstove program implementation. The recent development of carbon financed stove projects has rendered many such issues unresolved.

Ban Ki-moon’s statement at the beginning of this essay reflects a common discursive tone surrounding carbon financed improved cookstove programs; a tone that seems to imply an automatic ‘‘win’’ upon project implementation for everyone involved. Needless to say, this assumption gravely oversimplifies the complex network of social, ecological and economic actors and interactions that comprise such programs. There is indeed tremendous potential for both localized ‘‘intensive’’ benefits and also global ‘‘extensive’’ advantages emanating from scaled up carbon-financed simproved cookstove programs. And it is precisely the emergent and *promising* nature of these programs that lends a sense of opportunity and urgency to expedite their effective articulation.

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